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GOVT. POLICIES ON INFRASTRUCTURE DEVELOPMENT: KEY ISSUE TO PROMOTE ALTERNATIVE FUEL VEHICLES (AFV) IN INDIA

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ABSTRACT

In India transportation sector are consuming majority stake almost 57% of expensive imported oil. Due to bad road condition and lack of proper infrastructures fuel consumption of the vehicles is increasing. So, alternative fuels have received special attention since couple of years back around the world. The demands of alternative fuel vehicles are increasing rapidly to reduce automotive emission and to cartel the dependence on imported gasoline oil around the world. Many countries like US, Japan, UK, China and Brazil, Indian govt. also has been set up several plans to boost up this alternative fuel vehicle sector. Through National Bio-fuel Policy various state govt. are encouraging farmers to cultivate non edible oil seeds and also manufacturers to produce alternative fuel. In this paper we have discussed about various alternative fuels sources like Bio-diesel, Bio-ethanol, CNG, LPG and Electricity. This article discusses that what are impact of alternative fuel vehicles in the transportation industry and are they economically feasible to consumers? This paper also found out that why few govt. plans have failed, how much they have implemented and how far they have to go to achieve the target.

KEYWORDS: Alternative Fuel, Development, Govt. Policy, India, Infrastructure, Vehicle

INTRODUCTION

Energy is one of the most important building blocks in human development. India ranks sixth in terms of energy demand, accounting for 3.6% of total global energy demand. India's energy demand is expected to grow at 4.8% annually. Its dependence on oil imports will increase enormously in the near future because of rising population. It is predicted that if India continues at this rate, we would be consuming 5.6 million barrels of oil per day by 2030, out of which more than 94% will be met through oil imports. To reduce oil dependency and to make transport more sustainable, the govt. set out an objective to substitute 20% of petroleum fuel with alternative fuel by the year 2017 (Planning Commission report Govt. of India)[1]. India has huge potential for an alternative fuel based energy sector in terms of feeds stock availability. Bio-fuels, especially bio-ethanol and bio-diesel have a proven track record at the international level.

The Government of India's decision to blend 5% ethanol with petrol in several states is a major initiative in this direction. According to Planning Commission report, the Govt. of India has already set up a Bio-diesel Promotion Board under the chairmanship of Prime Minister of India. In a study of consumer behaviour and expectations, Kurani surveyed vehicle owners during the introduction of diesel vehicles in California and natural gas vehicle in New Zealand

[1] Planning Commission of India report of 2009-10.

(Kurani, 1992; Sperling and Kurani, 1987)[2]. Analysis of initial survey results suggested that concerns over refueling availability diminished rapidly after approximately 15 percent of existing stations provided the alternative fuel. In previous studies shows that, the measures directly targeting the consumer such price subsidy, gasoline taxes, subsidy on alternative fuels and allocation of express lanes dedicated for AFV's, are also being debated (Ewing and Sarigolli 2000)[3]. Many attempts have been made to promote alternative fuel but success stories like Brazil and Argentina tend to be exceptions among a bigger list of failure (Fracchia, 2000; Goldemberg et al., 2004)[4]. Public support for refueling stations alone does not assure success, as has been demonstrated with compressed natural gas vehicles in New Zealand and Canada, and methanol vehicle in California (Flyn, 2002; MacDonald, 2005; Yeh, 2007)[5]. Several other studies have discussed the chicken and egg problem associated with dedicated AFV's, which involves a bind between three major stakeholders: consumers reluctant to purchase vehicles that can not be refueled, vehicle manufacturers reluctant to produce vehicles that will not be purchased and fuel providers reluctant to provide fuels for vehicles that do not exist (Leiby and Rubin, 2004; Melaina, 2002; Sperling, 1988)[6].

Alternative Fuels

The entire surface transport of India is based on petroleum fuel, but its availability is of growing concern. The production of domestic crude has been declining and the transport system has been increasingly dependent on imported crude oil to meet its needs. There is a growing concern that the world may run out of petroleum based fuel resources. All these make it imperative that the search for alternative fuels is taken in right earnest. The alternative fuels aspiring to take the place of petroleum are-

Propane

Liquefied petroleum gas (LPG) consists mainly of propane, propylene, butane, and butylenes in various mixtures. It is produced as a by-product of natural gas processing and petroleum refining. With propane's simple molecular composition, propane - fueled vehicles emit significantly lower levels of carbon monoxide, hydrocarbons and nitrogen oxides than gasoline - fueled vehicles. The level of air - toxic emissions from propane -fueled vehicles is also low. According to the National Propane Gas Association, U.S.A., spark plugs from a propane vehicle last from 80,000 to 100,000 miles and propane engines can last two to three times longer than gasoline or diesel engines.

Ethanol

Ethanol (ethyl alcohol, grain alcohol, ETOH) is a clear, colorless liquid with a characteristic, agreeable odor. Two higher blends of ethanol, E-85 and E-95 are being explored as alternative fuels in demonstration programs. Ethanol is also made into ether, ethyl tertiary-butyl ether (ETBE) that has properties of interest for oxygenated gasoline and reformulated fuels. The environmental benefits of ethanol include: 10% ethanol blends reduce carbon monoxide better than any other reformulated gasoline blend. Ethanol is a safe replacement for toxic octane enhancers in gasoline such as

[2] Kurani, K., 1992. Application of a behavioral market segmentation theory to new transportation fuels in New Zealand. Ph.D. Dissertation, Institute of Transportation Studies, University of California, Davis, CA.

[3] Ewing, G., Sarigollu, E., "Assessing consumer preferences for clean-fuel vehicles: A discrete choice experiment", Journal of Public Policy and Marketing, Spring 2000, Vol. 19 (1), page no. 106-118.

[4] Fracchia, J.C., 2000. An Overview of the Argentine NGV Experience. World Bank Workshop on CNG Vehicles, Washington, DC.

[5] Flynn, P.C., 2002. Commercializing an alternative vehicle fuel: lessons learned from natural gas for vehicles. Energy Policy 30, 613–619.

[6] Leiby, P., Rubin, J., 2004. Understanding the transition to new fuels and vehicles: Lessons learned from analysis and experience of alternative fuel and hybrid vehicles.

benzene, toluene and xylem. ETBE lowers gasoline volatility and is, thus, particularly effective in reducing VOC emissions from automobiles.

Methanol

Methanol (CH3OH) is an alcohol fuel. As engine fuels, ethanol and methanol have similar chemical and physical characteristics. Methanol is methane with one hydrogen molecule replaced by a hydroxyl radical. It is produced from natural gas in production plants with 60% total energy efficiency. Methanol can be made with any renewable resource containing carbon such as seaweed, waste wood and garbage.

This is a promising alternative, with a diversity of fuel applications with proven environmental, economic and consumer benefits. It is widely used today to produce the oxygenate MTBE added to cleaner burning gasoline. Cars, trucks and buses running millions of miles on methanol have proven its use as a total replacement for gasoline and diesel fuels in conventional engines. Methanol offers the greatest hope for early and broad introduction of fuel cells that will make Electric Vehicles practical within the next few years. Whether reformed to provide hydrogen for conventional fuel cells or used directly in the latest liquid fed cells, methanol will overcome the greatest remaining obstacle to commercialization, by offering the only economical way to transport and store the hydrogen needed for fuel cells. Methanol fuel cells will greatly reduce carbon dioxide emissions for vehicles and virtually eliminate smog and particulate pollution.

Bio-Diesel

Bio-diesel (mono alkyl esters) is a cleaner-burning diesel fuel made from natural, renewable sources such as vegetable oils. Just like petroleum diesel, bio-diesel operates in combustion ignition engine. The use of bio-diesel in a conventional diesel engine results in substantial reduction of unburned hydrocarbons, carbon monoxide, and particulate matter. It also decreases the solid carbon fraction of particulate matter (since the oxygen in bio-diesel enables more complete combustion to CO2), eliminates the sulfate fraction (as there is no sulfur in the fuel), while the soluble, or hydrocarbon, fraction stays the same or is increased.

Electric Fuel

Electricity is unique among the alternative fuels in that mechanical power is derived directly from it, whereas the other alternative fuels release stored chemical energy through combustion to provide mechanical power. Batteries commonly provide electricity used to power vehicles, but fuel cells are also being explored. Batteries are energy storage devices, but unlike batteries, fuel cells convert chemical energy to electricity.

A large number of various types of batteries are being tested for use in EVs. Some of the technologies being used or evaluated include lead-acid, nickel cadmium, nickel iron, nickel zinc, nickel metal hydride, sodium nickel chloride, zinc bromine, sodium sulfur, lithium, zinc air, and aluminum air.

In the year 2012 Department of Heavy Industries, GOI had launched NEMMP 2020 to encourage electric vehicles (EVs) sector[7]. The first benefit of using electric fuel is that you are not polluting the environment. Although, some people argue that there are some emissions that can be attributed to EVs the emissions that are generated in the electricity production process at the power plants. The maintenance costs for EVs are less. EVs have fewer moving parts to service and replace.

[7] National Electric Mobility Mission Plan 2020 launched on August 2012 by the Ministry of Heavy Industries and Public Enterprise (DHI) GOI.

Hydrogen

Hydrogen gas (H2) is being explored for use in combustion engines and fuel-cell electric vehicles. It is a gas at normal temperatures and pressures, which presents greater transportation and storage hurdles than exist for the liquid fuels. Storage systems being developed include compressed hydrogen, liquid hydrogen, and chemical bonding between hydrogen and a storage material (for example, metal hydrides). While no transportation distribution system currently exists, for hydrogen transportation use, the ability to create the fuel from a variety of resources and its clean-burning properties make it a desirable alternative fuel. Increasing pollution from cars and airplanes has created smog clouds across the country. Hydrogen, on the other hand, emits no toxins, and is also clean and efficient.

Natural Gas (CNG / LNG)

Natural gas is a mixture of hydrocarbons-mainly methane (CH4)-and is produced either from gas wells or in con-guide with crude oil production. The interest for natural gas as an alternative fuel stems mainly from its clean burning qualities, its domestic resource base, and its commercial availability to end-users. Natural gas is the cleanest burning alternative fuel. Exhaust emissions from NGVs are much lower than those from gasoline-powered vehicles. For instance, NGV emissions of carbon monoxide are approximately 70 percent lower, non-methane organic gas emissions are 89 percent lower, and oxides of nitrogen emissions are 87 percent lower. In addition to these reductions in pollutants, NGVs also emit significantly lower amounts of greenhouse gases and toxins than do gasoline vehicles. Dedicated NGVs produce little or no evaporative emissions during fueling and use. For gasoline vehicles, evaporative and fueling emissions account for at least 50 percent of a vehicle's total hydrocarbon emissions. Dedicated NGVs also can reduce carbon dioxide exhaust emissions by almost 20 percent vehicles.

Govt. Policy on Bio-Fuel

In 2003, the Planning Commission of India brought out an extensive report on the development of bio-fuels (Planning Commission)[8]. The National Bio-diesel Commission was set up to look exclusively into issues pertaining to Bio-diesel and the development of Jatropha curcas as the feedstock for Bio-diesel production (Planning commission, 2003). The blending targets for ethanol and Bio-diesel were proposed to be set at 10 and 20% respectively by 2011/12.

Developments in National Bio-Diesel Mission (NBM)

Table 1

Period	Action
2003	Introducing time frame 2003 to 2007: The Ministry of Rural Development appointed as a nodal ministry to cover 400,000 hectares under jatropha cultivation. This phase also proposed nursery development, establishment of seed procurement and establishment centers, installation of a trans-esterification plant, blending and marketing of Bio-diesel.
2005	Ministry of Petroleum and Natural Gas (MoPNG) announced a bio-diesel purchase policy in which Oil Marketing Companies (OMC) would purchase Bio-diesel across 20 procurement centers across the country to blend with high speed diesel w.e.f January 2006. Purchase price set at Rs. 26.5 per liter.
2008	Self Sustaining Execution phase 2008 to 2012: Targeted to produce sufficient Bo-diesel for 20 percent blending by the end of XIth (2008-12) five year plans.
2010	An estimated 0.5 million hectares has been covered under jatropha cultivation of which two third is estimated to be new plantation requiring two to three years to mature.
2011-12	Ambitious plans to ensure sufficient feedstock by 2011-12 for 20% mandate fuel blends.

Source: National Oil Seed and Vegetable Oil Development Board (NOVODB) Report

[8] Planning Commission of India report of 2003.

Ethanol Blending Program (EBP)

EBP is an ambitious plan from GOT involving a mandatory 5% blend of ethanol derived from sugar molasses with petrol.

Table 2

Period	Action
January 2003	Ministry of Petroleum and Natural Gas (MoPNG) made 5% Ethanol blending in petrol mandatory across 9 States 5 Union Territories.
September 2006	Resurgence in sugarcane production in 2005-2006 and 2006-2007 led the GOI to mandate 5% ethanol blending in gasoline across 20 states and 8 Union Territories subject to commercial viability
September 2008	The Union Cabinet approved the National Bio-fuel Policy. Five percent blending became mandatory across all states in the country. The third phase of implementing EBP envisaged the blending ratio to be increased to 10% with a targeted 20% blending by 2017.
July 2010	Establishment of an expert committee by GOI to recommended a long term formula for fixing the price of ethanol.

Source: Planning Commission of India Report, 2012

Ethanol

India has 330 distilleries which can produce over 4 billion liters of rectified spirit (alcohol) per year in addition to 1.5 billion liters of fuel ethanol. Of this total, about 140 have the capacity to distill around 2 billion liters [12] of conventional ethanol per year and could meet the demand for 5-percent blending with gasoline. Currently, India produces conventional bio-ethanol from sugar molasses; production of advanced bio-ethanol is in a nascent phase (research and development).

Table 3: India: Conventional Bio-Ethanol Production and Distribution (Million Liters)

Calendar Year	2006	2007	2008	2009	2010	2011	2012	2013
Beginning Stocks	483	747	1,396	1,672	1,241	1,065	756	911
Production	1,898	2,398	2,150	1,073	1,522	1,681	2,170	2,239
Imports	29	15	70	280	92	20	80	50
Total Supply	2,410	3,160	3,616	3,025	2,855	2,766	2,901	2,995
Exports	24	14	3	4	10	15	10	15
Consumption								
Industrial Use	619	650	700	700	720	700	720	740
Potable Liquor	745	800	850	880	900	850	880	910

Source: FAS/New Delhi Estimates Based on Information from Trade Sources. Here Molasses Used as Feedstock

Infrastructure for Alternative Fuel Vehicles (AFV)

Conventional transport fuel system faces a number of long term challenges, including climate change, urban air pollution, energy security, limited expensive oil resources and continued growth in demand for transportation sector (Melaina and Bremson, 2008)[9]. Establishing a necessary level of refueling availability is one of the many inputs required to support the AFV technology innovation process (Norberg-Bohm, 2002; PCAST, 1999; Popper and Wagner, 2002)[10]. In India alternative fuel sources are many but availability of alternative fuel vehicles are limited in the market.

[9] Melaina, M., Bremson, J., 2008. 'Refueling availability for alternative fuel vehicle markets: Sufficient urban station coverage', Elsevier, Energy Policy 36, 3233-3241.

[10] Norberg-Bohm, V. (Ed.), 2002. The Role of Government in Energy Technology Innovation: Insights for Government Policy in the Energy Sector. BSCIA Working Paper 2002-14, Energy Technology Innovation Project, Belfer Center for Science and International Affairs.

In electric car segment Mahindra REVA is the only car which available in the Indian market. One electric car owner can not recharge their car in any petrol pump due to lack of proper infrastructure. Like this many other reasons are there for not adopting electric vehicles (EV) by Indian consumers.

Now-a-days worlds leading automobile manufacturers are producing conventional model (Petrol/Diesel) as well as alternative fuel version. Recently TATA Motors had launched CNG version of their NANO car segment in limited parts of India. The main reason behind this, that CNG refueling station is not available all through out India. Automobile majors like Maruti Suzuki, Hyundai Motors, General Motors, Honda, Bajaj Auto etc are manufacturing both LPG and CNG version of their models (IAC report, 2013)[11]. In India, CNG refueling stations are concentrated only five to six states where more than nine hundred LPG refueling stations are covered all most every state.

Findings

Government unveiled its National Bio-fuel Policy in October 2008 but after a long period of five years, it is clear that the government still has a long way to go. Oil companies have sourced just 440 million liters of ethanol as against the 1.05 billion liters target for the five per cent mix. The blended petrol is available only in 13 states, and even there, the extent of blending is just 2 per cent. It is estimated that transport sector is consuming 57% of total petroleum products in India. The energy demand across transport sector is the highest among other sector like Industry, domestic, agriculture etc. Roads, being one of the dominant infrastructures for transport, carry an estimated 85 to 90 percent of the country's passenger traffic and 65 % of its freight. Traffic on roads is growing at a rate of 7 % to 10 % per year, while the vehicle growth is of the order of 8 % to 10 % per year (PPAC report, 2012-13)[12]. Diesel demands during the 12th Five-year plan (fiscal year 2012-13 to 2016-17) are likely to grow by 35 % 87.4 million tons. Meeting a 5 % blending target will require an additional 4.1 million hectares under jatropha (MoPNG)[13]. Though the sugarcane (main source of ethanol) is a highly water intensive crop and as much of this types of land is not available so govt. need to bring some land under irrigation. Many sugar mills are exporting molasses, which is a by product of sugar, to the European countries as a cattle food for earn foreign currency thus the ethanol production is badly affected due to shortages of raw materials (molasses).

Considering higher consumption of petrol/diesel for road transport, India should take an immediate fiscal policy measure which is an integral part of bio-diesel mission. Budgetary support should be an integral part of any bio-fuel policy for a bio-fuel cultivator to support livelihood during gestation period. It is needed to remove all central taxes on bio-diesel and ensure a uniform 0 % sale tax (VAT) on the product across states. Except for a concessional excise tax of 16 percent on bio-ethanol, no other central taxes and duties are proposed to be levied on bio-diesel and bio-ethanol (GAIN report, 2012). As on date the cultivation is mainly hit by lack of R&D and minimum price support for farmers. As a protection measure for domestic producers, govt. should increase 100 % import duty on bio-diesel (Paul, 2009)[14]. The Gov. of India proposes to create a National Bio-fuel Fund for providing financial incentives, including subsidies and grants, for new and second generation feedstock's, advanced technologies, conversion processes and production units. (GAIN report, 2012)[15].

Suggestions

Government support for the adoption of alternative fuels may involve a wide range of options, including financial

[11] Indian Auto LPG Coalition (IAC) report, 2013.
[12] Petroleum Planning and Analysis cell (PPAC), GOI report.
[13] Ministry of Petroleum and Natural Gas (MoPNG) report, 2013.
[14] Paul, A. Government restriction on sale of bio-diesel disrupts production, posted: Thursday, 11th June, 2009.
[15] Global Agricultural Information Network (GAIN), USDA Foreign Agricultural Service. GAIN report no. IN2081, 2012.

incentives, mandates, development of codes and standards, labeling and certification and stakeholder's coordination (Melaina and Bremson, 2008)[16]. Governments across the globe promote alternative fuels through several fiscal and Non-fiscal incentives, these are:

- Sales Tax and Excise duty exemption or rebate.
- Govt. should declare the bio-fuels under the ambit of 'Declared Goods' category.
- Govt. should control the movement of molasses (raw material of Ethanol) to the foreign countries.
- Road / registration tax exemption or rebate.
- Vehicle sales tax exemption income/profit tax credit for purchasers and original equipment manufacturers (OEMs).
- Tax credit to companies for investment in distribution channels and infrastructure development.
- Govt. should implement minimum support price (MSP) as per market price to the bio-fuel crop growers (farmers) as well as bio-fuel manufacturers.
- Grants/Tax credits for vehicle conversions to CNG/LPG or purchases.
- Exemption from parking or road use charges.
- Govt. may impose 'Green Tax' for clean air on all the petrol/diesel vehicle users in highly populated cities like Mumbai, Delhi, Kolkata, Chennai, Pune, Hyderabad etc.

CONCLUSIONS

Emerging economies like India, the urgency to find viable alternatives for sustainable mobility is also accentuated by rapid economic development which is accelerating the demand for transportation. Indian economy and growth is totally depending on highly expensive imported crude oil. Being the world's fifth largest primary energy consumer and forth largest petroleum consumer after United States, China and Japan, India should focus on alternative fuels. India's economy is badly affected by the international crude oil prices fluctuation time to time.

So, now the time is to reform the govt. policies regarding infrastructure development to boost up alternative fuel vehicles sectors. Adequate refueling availability is fundamental to the commercialization of AFV's. Owners of alternative fuel vehicles are more likely to use alternative fuels if retail stations are prevalent. The adoption of dedicated AFV's which rely exclusively on an alternative fuel, is wholly contingent on refueling availability consumers will not purchase vehicles that they can not refuel.

REFERENCES

1. Ewing, G., Sarigollu, E., "Assessing consumer preferences for clean-fuel vehicles: A discrete choice experiment", Journal of Public Policy and Marketing, Spring 2000, Vol. 19 (1), page no. 106-118.
2. Fracchia, J.C., 2000. An Overview of the Argentine NGV Experience. World Bank Workshop on CNG Vehicles, Washington, DC.

[16] Melaina, M., Bremson, J., 2008. 'Refueling availability for alternative fuel vehicle markets: Sufficient urban station coverage', Elsevier, Energy Policy 36, 3233-3241.

3. Flynn, P.C., 2002. Commercializing an alternative vehicle fuel: lessons learned from natural gas for vehicles. Energy Policy 30, 613–619.

4. GAO, 2000. Energy Policy Act of 1992: Limited Progress in Acquiring Alternative Fuel

5. Vehicles and Reaching Fuel Goals. General Accounting Office, Washington, DC. Goldemberg, J., Coelho, S.T., Lucon, O., 2004. How adequate policies can push renewable. Energy Policy 32, 1141–1146.

6. Global Agricultural Information Network (GAIN), USDA Foreign Agricultural Service. GAIN report no. IN2081, 2012.

7. Indian Sugar Mill Association (ISMA) report, 2012.

8. Indian Auto LPG Coalition (IAC) report, 2013. (www.iac.org.in/auto-lpg-in-india)

9. Kurani, K., 1992. Application of a behavioral market segmentation theory to new transportation fuels in New Zealand. Ph.D. Dissertation, Institute of Transportation Studies, University of California, Davis, CA.

10. Leiby, P., Rubin, J., 2004. Understanding the transition to new fuels and vehicles: Lessons learned from analysis and experience of alternative fuel and hybrid vehicles. In: Sperling, D., Cannon, J.S. (Eds.), 'The Hydrogen Energy Transition: Moving Toward the Post Petroleum Age in Transportation'. Elsevier Academic Press, Burlington, MA.

11. Ministry of New and Renewable Energy (MoNRE), 2008. National Policy on Bio-fuels, govt. of India. Available from (www.mnre.gov.in/policy/biofuel-policy.pdf)

12. Ministry of Petroleum and Natural Gas (MoPNG), 2000. India Hydrocarbon Vision 2025.

13. Ministry of Petroleum and Natural Gas (MoPNG), 2005. Bio-diesel Purchase Policy, govt. of India. Available from (www.petroleum.nic.in/Bio-diesel.pdf).

14. Melaina, M.W., 2002. Initiating hydrogen infrastructures: preliminary analysis of a sufficient number of initial hydrogen stations in the US, Market Challenges of Fuel Cell Commercialization. Berlin.

15. MacDonald, T., 2005. Alcohol Fuel Flexibility—Progress and Prospects, Staff Paper.

16. California Energy Commission, Transportation Fuels Division.

17. Melaina, M., Bremson, J., 2008. 'Refueling availability for alternative fuel vehicle markets: Sufficient urban station coverage', Elsevier, Energy Policy 36, 3233-3241.

18. Norberg-Bohm, V. (Ed.), 2002. The Role of Government in Energy Technology Innovation: Insights for Government Policy in the Energy Sector. BSCIA Working Paper 2002-14, Energy Technology Innovation Project, Belfer Center for Science and International Affairs.

19. Paul, A. Government restriction on sale of bio-diesel disrupts production, posted: Thursday, 11th June, 2009. (http://www.livemint.com/2009/06/11003630)

20. Petroleum Planning and Analysis cell (PPAC), GOI, (www.ppac.org.in)

21. Popper, S.W., Wagner, C.S., 2002. New Foundations for Growth: The US Innovation System Today and Tomorrow. Science and Technology Policy Institute, RAND, Arlington, VA.

22. PCAST, 1999. Powerful Partnerships: The Federal Role in International Cooperation on Energy Innovation. President's Committee of Advisors on Science and Technology, Washington, DC.

23. Planning Commission of India report of 2003, 2005, 2007, 2009, 2010-11.

24. Sperling, D., Kurani, K., 1987. Refueling and the vehicle purchase decision: the diesel car case. Society of Automotive Engineering Technical Paper no. 870644.

25. Sperling, D., 1988. New Transportation Fuels: A Strategic Approach to Technological Change. University of California Press, Berkeley, CA.

26. Yeh, S., 2007. An empirical analysis on the adoption of alternative fuel vehicles: the case of natural gas vehicles. Energy Policy 35, 5865–5875.